All questions are for separate science students only

Q1.

This question is about elements, compounds and mixtures.

(a) Substance **A** contains only one type of atom.

Substance **A** does **not** conduct electricity.

Which type of substance is **A**?

Tick (✓) **one** box.

Compound	☐
Metallic element	☐
Mixture	☐
Non-metallic element	☐

(1)

(b) Substance **B** contains two types of atoms.

The atoms are chemically combined together in fixed proportions.

Which type of substance is **B**?

Tick (✓) **one** box.

Compound	☐
Metallic element	☐
Mixture	☐
Non-metallic element	☐

(1)

(c) What is the name of the elements in Group 0 of the periodic table?

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

Noble gases ☐

Transition metals ☐

(1)

(d) Which statement about the elements in Group 0 is correct?

Tick (✓) **one** box.

All elements in the group are very reactive. ☐

All elements in the group form negative ions. ☐

The boiling points increase down the group. ☐

The relative atomic masses (A_r) decrease down the group. ☐

(1)

(e) Neon is in Group 0.

What type of particles are in a sample of neon?

Tick (✓) **one** box.

Atoms ☐

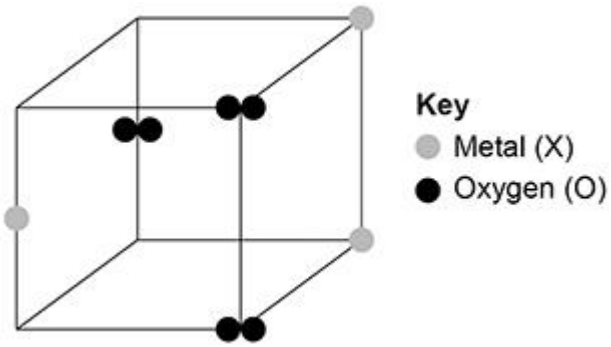
Ions ☐

Molecules ☐

(1)

(f) **Figure 1** represents part of the structure of an oxide of a metal.

Figure 1



Determine the empirical formula of this oxide.

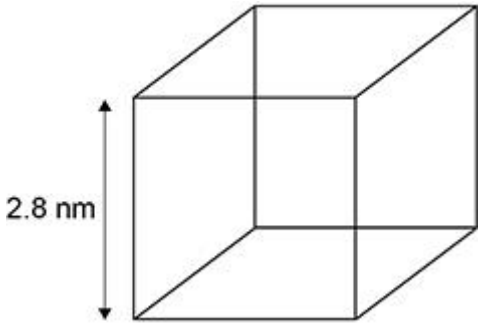
Empirical formula = XO___

(1)

A nanoparticle of a metallic element is a cube.

Figure 2 shows a diagram of the nanoparticle.

Figure 2



(g) The surface area of a cube is given by the equation:

surface area = (length of side)^2 × 6

Calculate the surface area of the cube in **Figure 2**.

Give your answer to 2 significant figures.

Surface area (2 significant figures) = _____ nm^2

(3)

(h) Fine and coarse particles of the metallic element are also cubes.

The length of a fine particle cube is 10 times smaller than the length of a coarse particle cube.

How does the surface area to volume ratio of the fine particle cube compare with that of the coarse particle cube?

Tick (✓) **one** box.

Both surface area to volume ratios are the same.	☐
The surface area to volume ratio of the fine particle is 10 times greater.	☐
The surface area to volume ratio of the fine particle is 10 times smaller.	☐

(1)

(Total 10 marks)

Q2.

This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour 40 cm^3 of hydrochloric acid into a conical flask.
2. Add 10.0 g of small calcium carbonate lumps to the conical flask.
3. Attach a gas syringe to the conical flask.
4. Measure the volume of gas produced every 30 seconds for 180 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

The student calculated the number of moles of gas from each volume of gas measured.

The table below shows the student's results for large calcium carbonate lumps.

Time in seconds	Number of moles of gas
0	0.0000
30	0.0011
60	0.0020

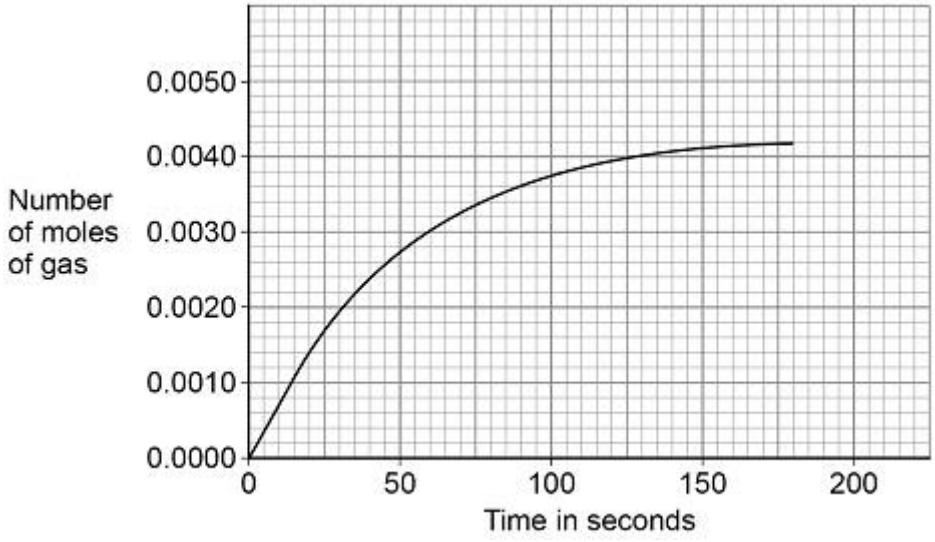
90	0.0028
120	0.0034
150	0.0038
180	0.0040

The student plotted the results for small calcium carbonate lumps on the graph below.

(a) Complete the graph below.

You should:

- plot the data for large calcium carbonate lumps from the table above
- draw a line of best fit.



(3)

(b) Determine the mean rate of reaction for **small** calcium carbonate lumps between 20 seconds and 105 seconds.

Give the unit.

Use the graph above.

Mean rate of reaction = _____ Unit _____

(4)

(c) The student concluded that the large calcium carbonate lumps reacted more slowly than the small calcium carbonate lumps.

How do the student's results show that this conclusion is correct?

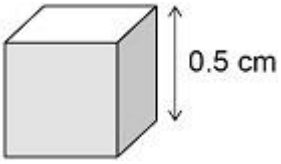
_____

_____

(1)

The difference in the rates of reaction of large lumps and of small lumps of calcium carbonate depends on the surface area to volume ratios of the lumps.

The diagram below shows a cube of calcium carbonate.



(d) Calculate the surface area to volume ratio of the cube in above diagram.

Give your answer as the simplest whole number ratio.

_____

_____

_____

_____

_____

Surface area : volume = _____ **:** _____

(3)

(e) A larger cube of calcium carbonate has sides of 5 cm

Describe how the surface area to volume ratio of this larger cube differs from that of the cube shown in the diagram above.

_____

_____

(1)

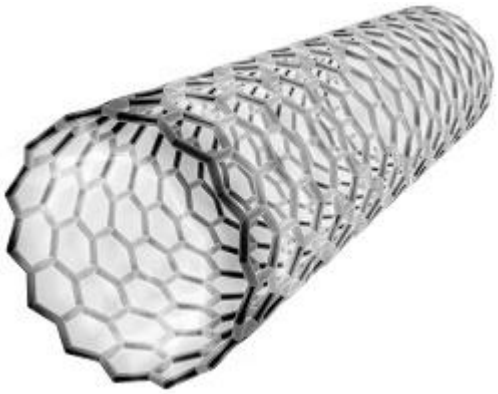
(Total 12 marks)

Q3.

This question is about materials and their properties.

(a) **Figure 1** shows a carbon nanotube.

Figure 1



The structure and bonding in a carbon nanotube are similar to graphene.

Carbon nanotubes are used in electronics because they conduct electricity.

Explain why carbon nanotubes conduct electricity.

_____

_____

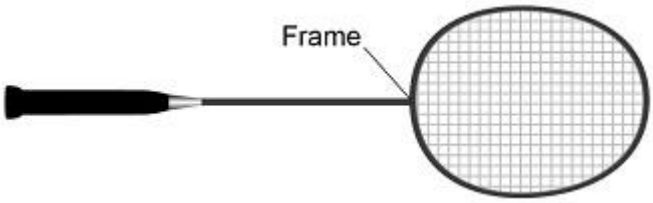
_____

_____

(2)

(b) **Figure 2** shows a badminton racket.

Figure 2



The following table shows some properties of materials.

The materials could be used to make badminton racket frames.

Material	Density in g/cm^3	Relative strength	Relative stiffness
Aluminium	2.7	0.3	69
Carbon nanotube	1.5	60	1000
Wood	0.71	0.1	10

Evaluate the use of the materials to make badminton racket frames.

Use the table above.

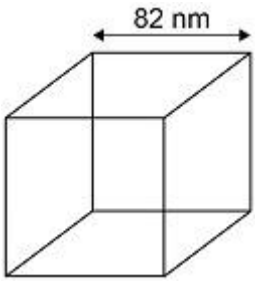
(4)

Zinc oxide can be produced as nanoparticles and as fine particles.

(c) A nanoparticle of zinc oxide is a cube of side 82 nm

Figure 3 represents a nanoparticle of zinc oxide.

Figure 3



Calculate the surface area of a nanoparticle of zinc oxide.

Give your answer in standard form.

_____

Surface area = _____ nm^2

(1)

(d) Some suncreams contain zinc oxide as nanoparticles or as fine particles.

Suggest **one** reason why it costs less to use nanoparticles rather than fine particles in suncreams.

_____

_____

(1)

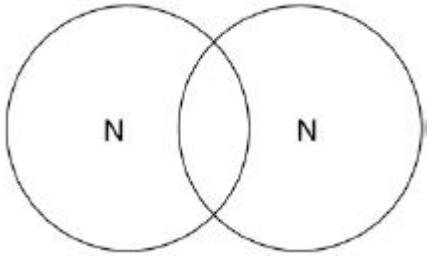
(Total 10 marks)

Q4.

This question is about structure and bonding.

(a) Complete the dot and cross diagram to show the covalent bonding in a nitrogen molecule, N_2

Show only the electrons in the outer shell.



(2)

(b) Explain why nitrogen is a gas at room temperature.

Answer in terms of nitrogen's structure.

_____

_____

_____

_____

_____

_____

(3)

(c) Graphite and fullerenes are forms of carbon.

Graphite is soft and is a good conductor of electricity.

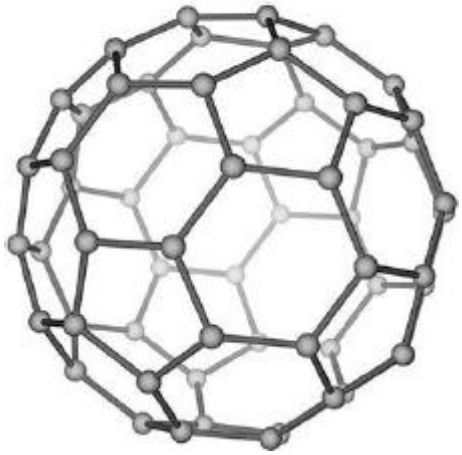
Explain why graphite has these properties.

Answer in terms of structure and bonding.

(4)

(d) **Figure 1** shows a model of a Buckminsterfullerene molecule.

Figure 1



A lubricant is a substance that allows materials to move over each other easily.

Suggest why Buckminsterfullerene is a good lubricant.

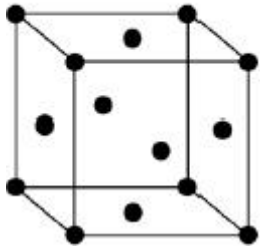
Use **Figure 1**.

(2)

Silver can form cubic nanocrystals.

Figure 2 represents a silver nanocrystal.

Figure 2



(e) A silver nanocrystal is a cube of side 20 nm

Calculate the surface area to volume ratio of the nanocrystal.

_____

_____

_____

_____

_____

Surface area to volume ratio = _____

(3)

(f) Silver nanoparticles are sometimes used in socks to prevent foot odour.

Suggest why it is cheaper to use nanoparticles of silver rather than coarse particles of silver.

_____

_____

_____

_____

(2)

(Total 16 marks)

Q5.

The figure below shows magnesium burning in air.

(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

_____

_____

(1)

(b) Name the product from the reaction of magnesium in the figure.

_____

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

The reaction is reversible ☐

The reaction has a high activation energy ☐

The reaction is exothermic ☐

Magnesium has a high melting point ☐

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1 ☐

4 ☐

7 ☐

9 ☐

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements ☐

They are highly reactive ☐

They have a low melting point ☐

They have a high surface area to volume ratio ☐

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

_____

_____

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

_____

_____

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q6.

This question is about atoms, molecules and nanoparticles.

(a) Different atoms have different numbers of sub-atomic particles.

(i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

_____

_____

_____

_____

_____

_____

_____

(2)

(ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

_____

_____

_____

_____

_____

_____

_____

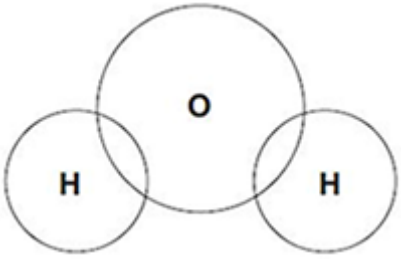
_____

(3)

(b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

(i) Complete the figure below to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.



(2)

(ii) Name the type of bonding in a molecule of water.

_____

(1)

(iii) Why does pure water **not** conduct electricity?

_____

_____

_____

(1)

(c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

(i) How does the size of a nanoparticle compare with the size of an atom?

_____

_____

_____

(1)

(ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1g of cobalt oxide powder.

_____

_____

_____

(1)

(Total 11 marks)